SEISMIC ATTENUATION AND VELOCITY DISPERSION DUE TO SQUIRT FLOW IN CRACKS WITH ROUGH WALLS

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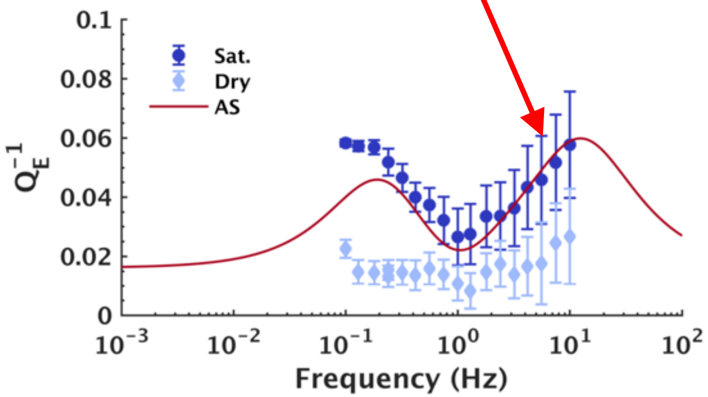
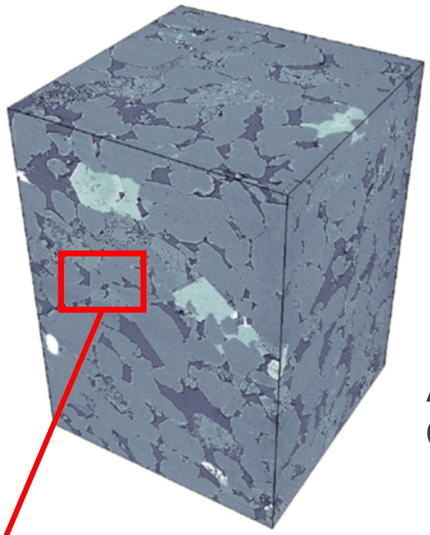
Motivation

Possible evidence of squirt-flow in Berea Sandstone



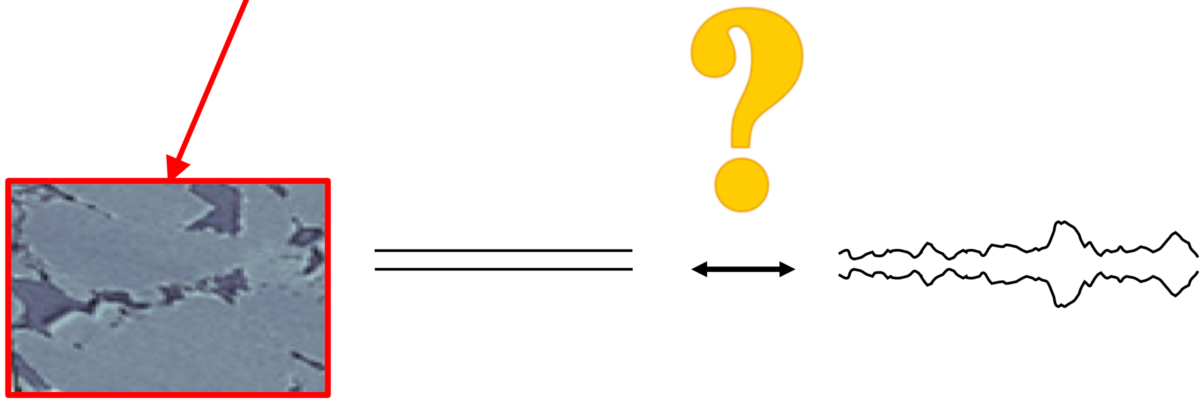
Chapman et al. (2018, Geophysical Prospecting)

CT scan of Berea Sandstone



Andrä et al. (2012, Computers & Geosciences)

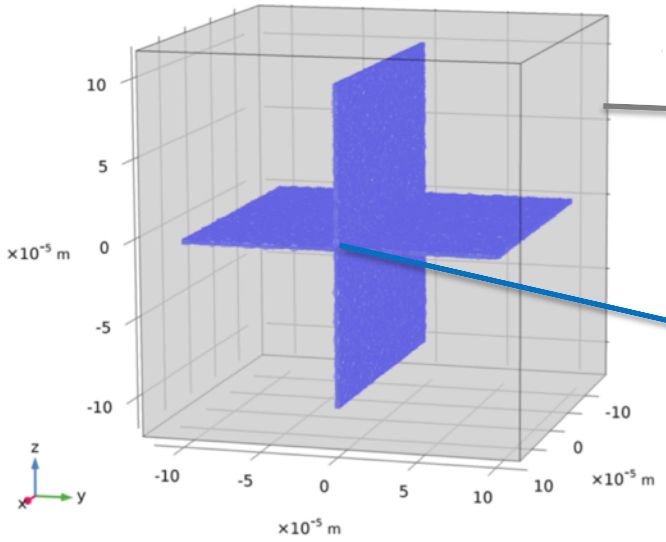
Which are the effects of **crack walls roughness** on their seismic response due to squirt-flow?



Numerical methodology

- **Equations**

following Quintal et al. (2019, Geophysical Prospecting)



Conservation of momentum, $\nabla \cdot \boldsymbol{\sigma} = 0,$

Non-porous solid elastic background: **Hooke's law**

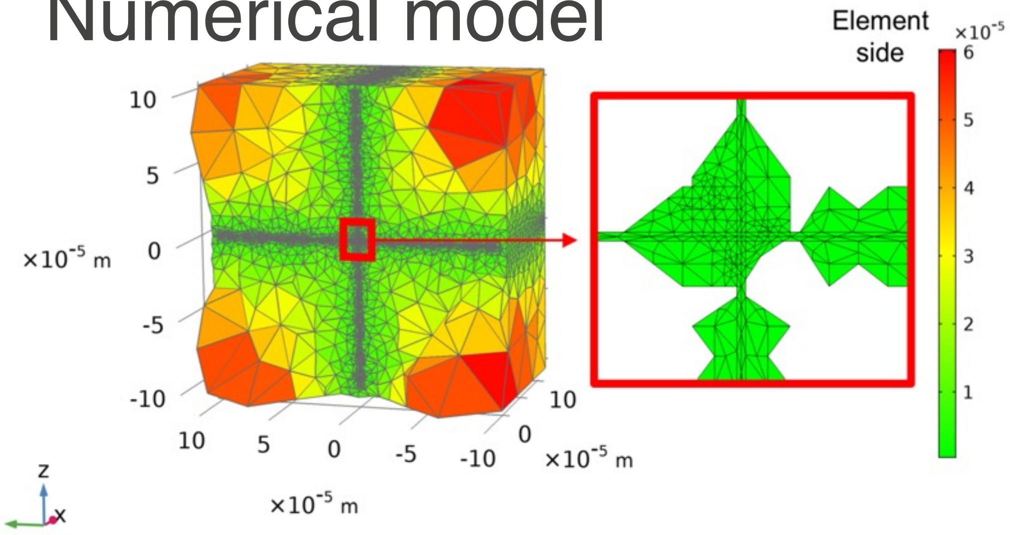
$$\sigma_{kl} = 2\mu\epsilon_{kl} + \lambda e\delta_{kl},$$

Inside the cracks

$$\sigma_{kl} = Ke\delta_{kl} + 2i\omega\eta\epsilon_{kl} - \frac{2}{3}i\omega\eta e\delta_{kl},$$

quasi-static, **linearized Navier-Stokes equations**.

- **Numerical model**



Effective complex P-wave modulus (H):

$$H = \frac{<\sigma_{zz}(\omega)>}{<\epsilon_{zz}(\omega)>}$$

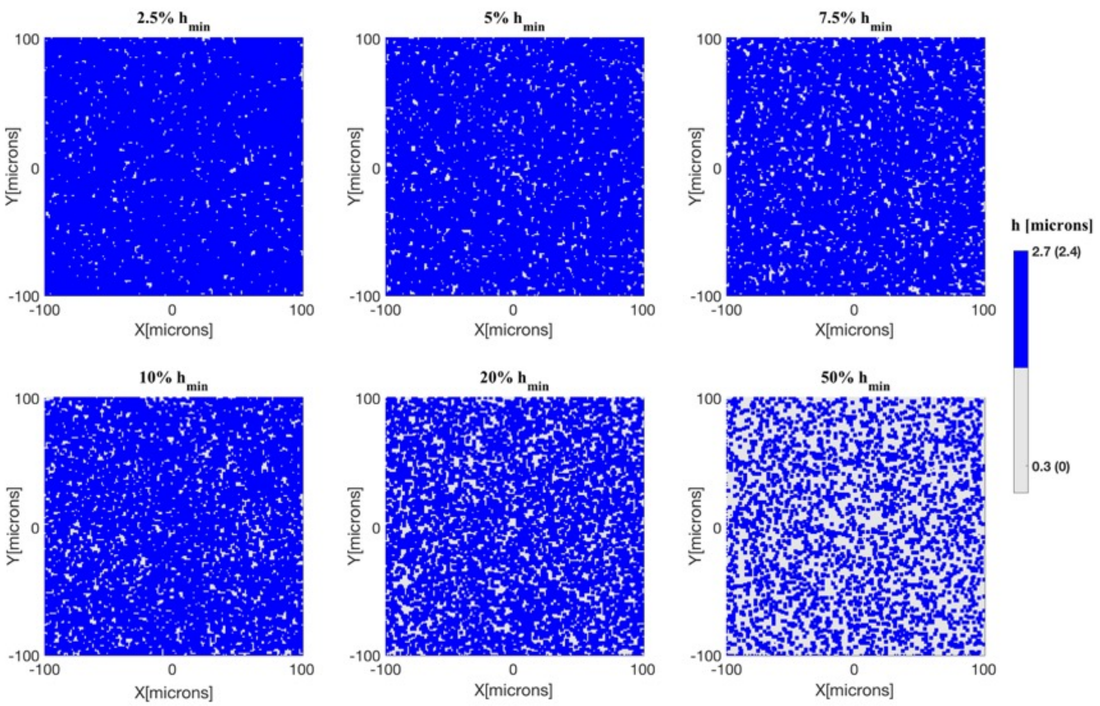
Seismic attenuation:

$$Q_p^{-1} = \frac{<Im\{H(\omega)\}>}{<Re\{H(\omega)\}>}$$

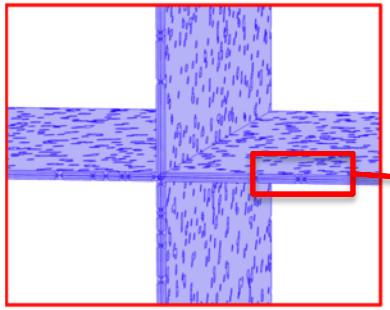
Table1: Material properties

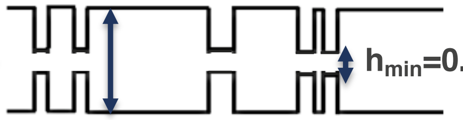
Properties	Background	Fluid
Bulk modulus [GPa]	35	4.35
Shear modulus [GPa]	40	0
Viscosity [Pa·s]	0	1

Model having Binary crack walls

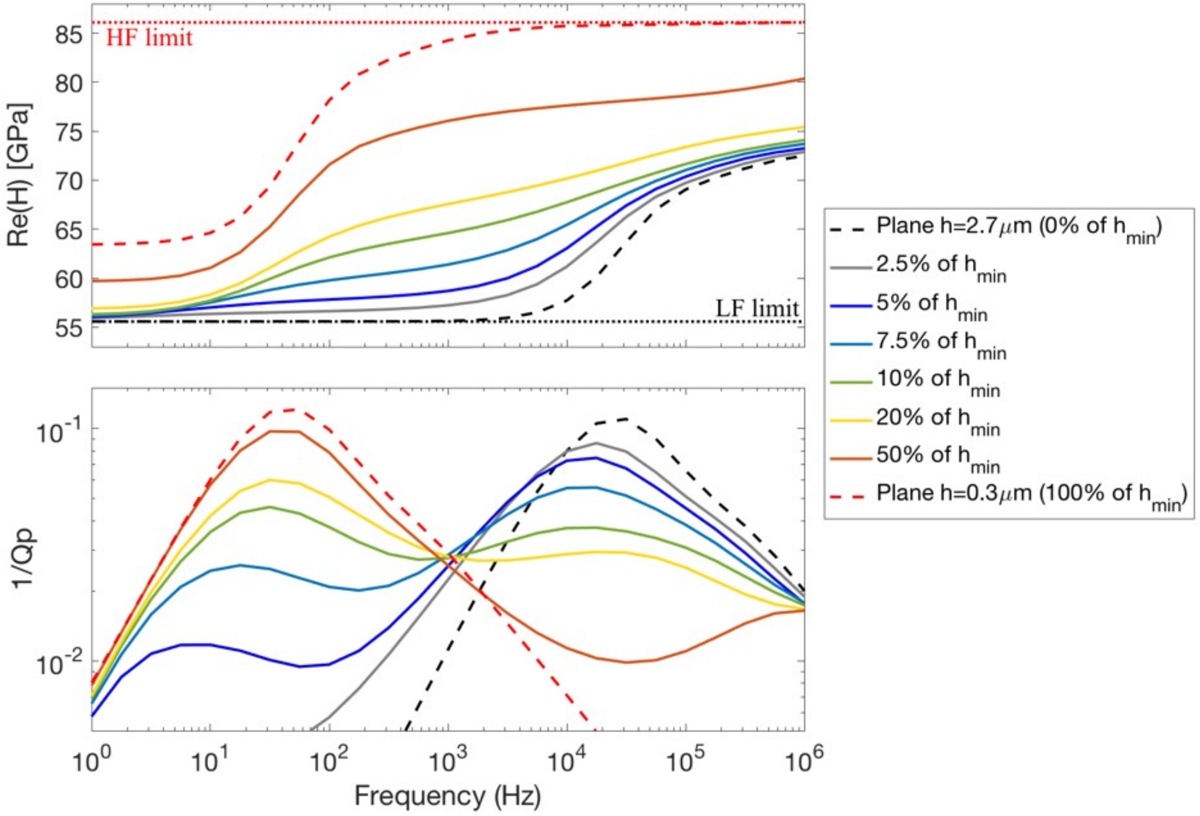


Using these crack aperture distributions, we build up the numerical models



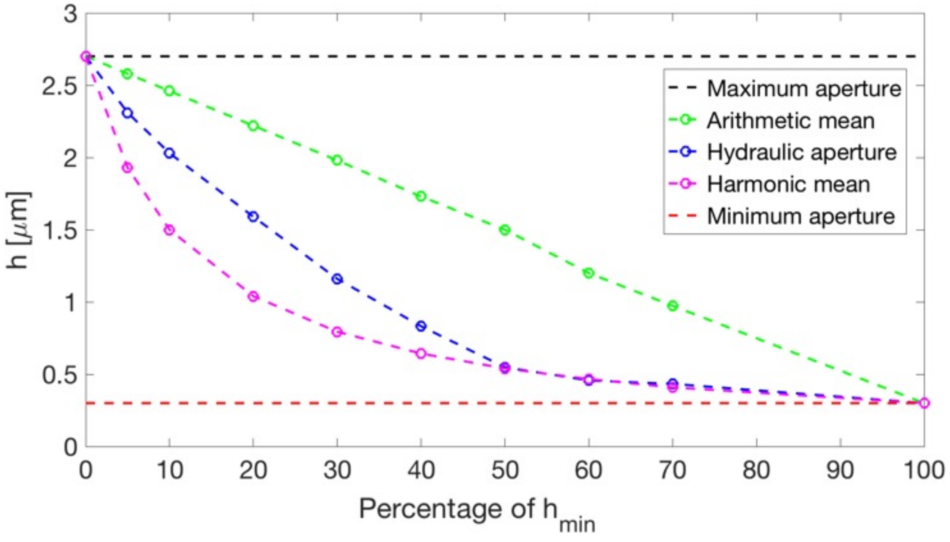


Results

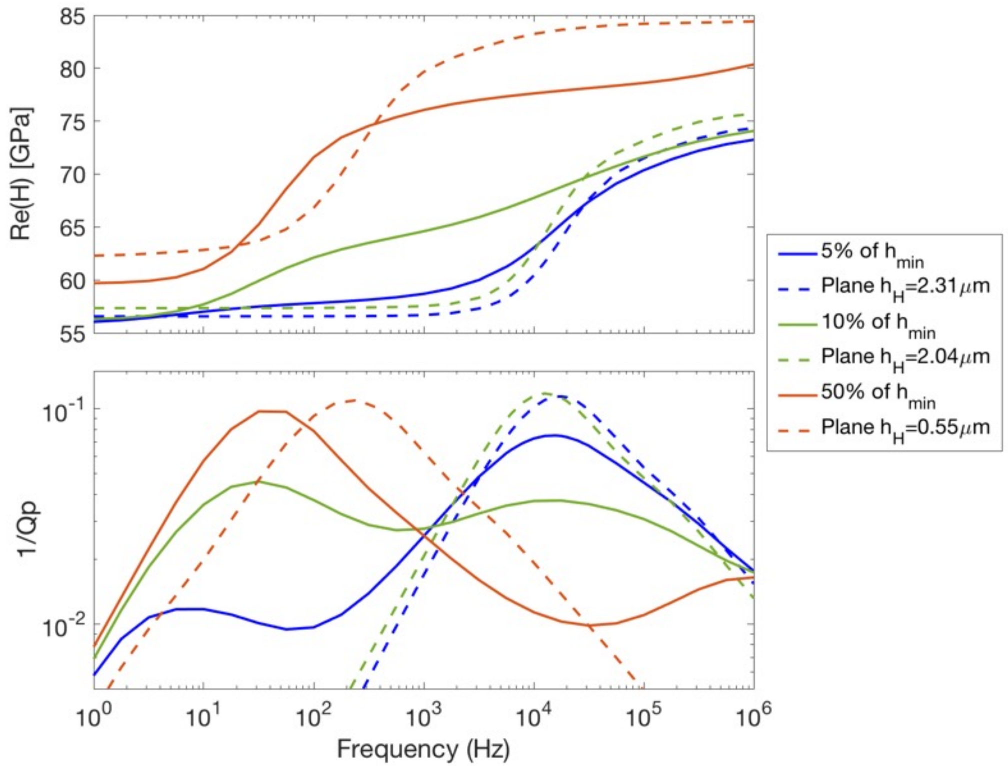


Link of the binary-crack model results with their hydraulic aperture (h_H)

Apertures of the model as functions of their percentage of minimum aperture (i.e., h_{min}=0.3 μm)



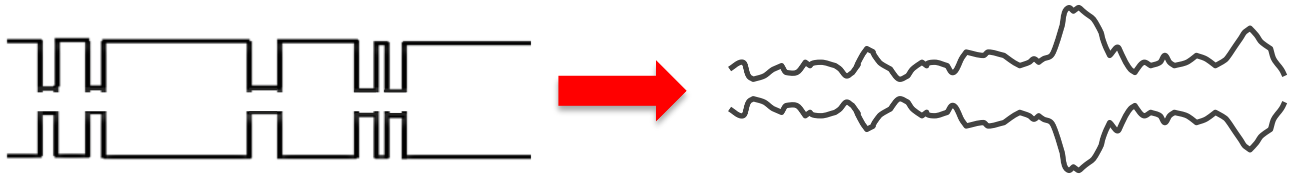
Results

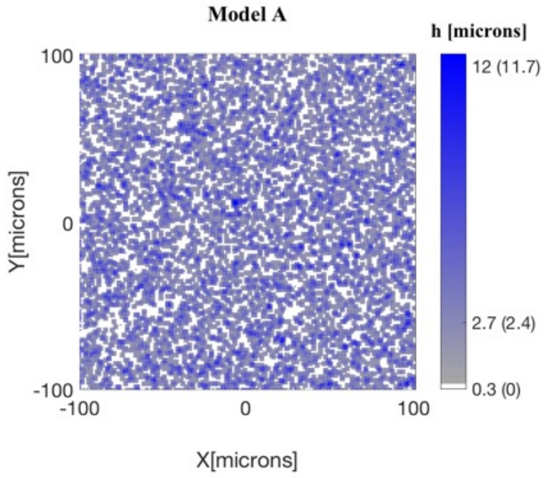


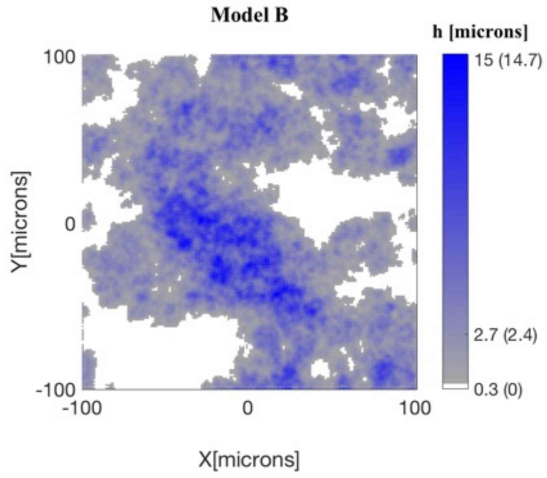
Binary-crack models summary:

- **From ~20% of h_{min}** in the crack aperture, the low-frequency peak corresponding to **h_{min} dominates the attenuation** curve.
- **Not always** the f_c of the **attenuation** curve can be used to infer the **hydraulic aperture**.

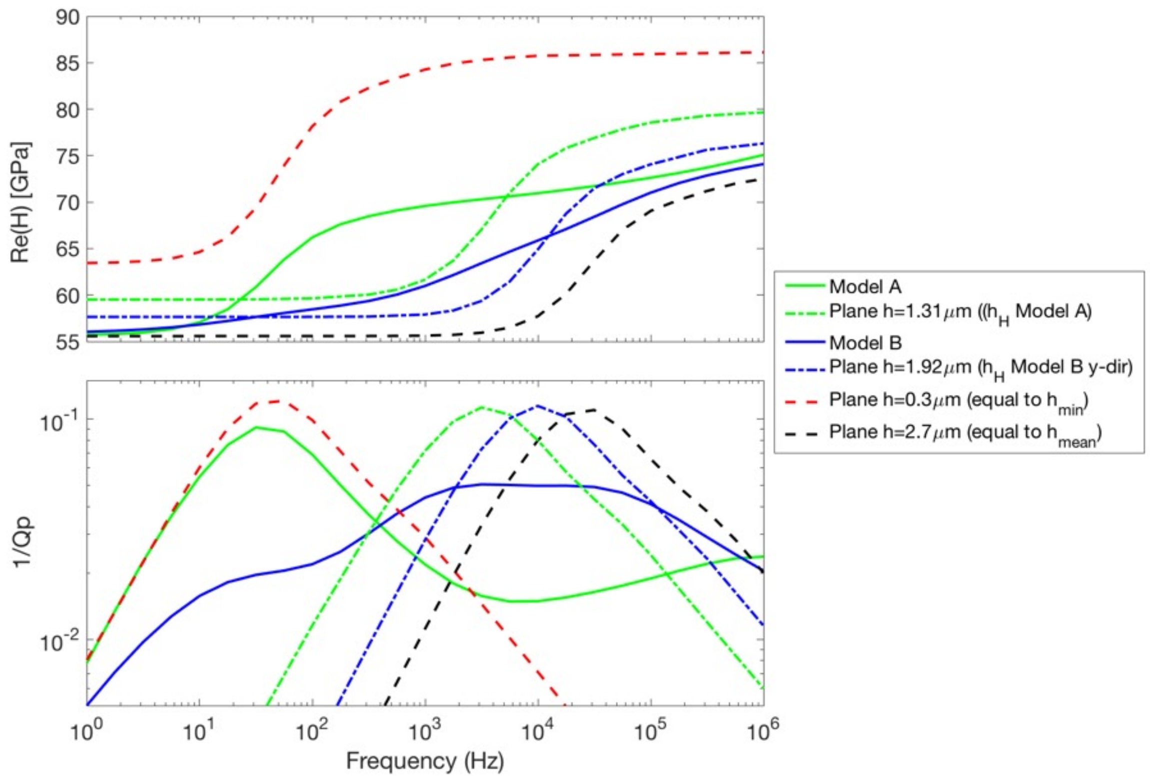
Models having fully-variable crack apertures linked with their hydraulic aperture (h_H)





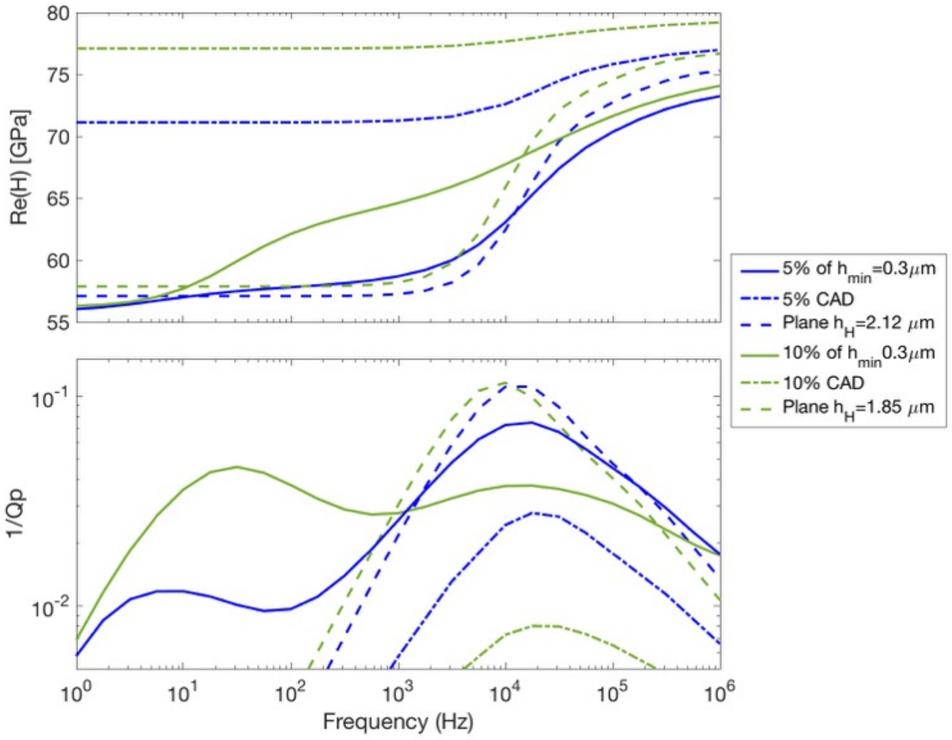


Results

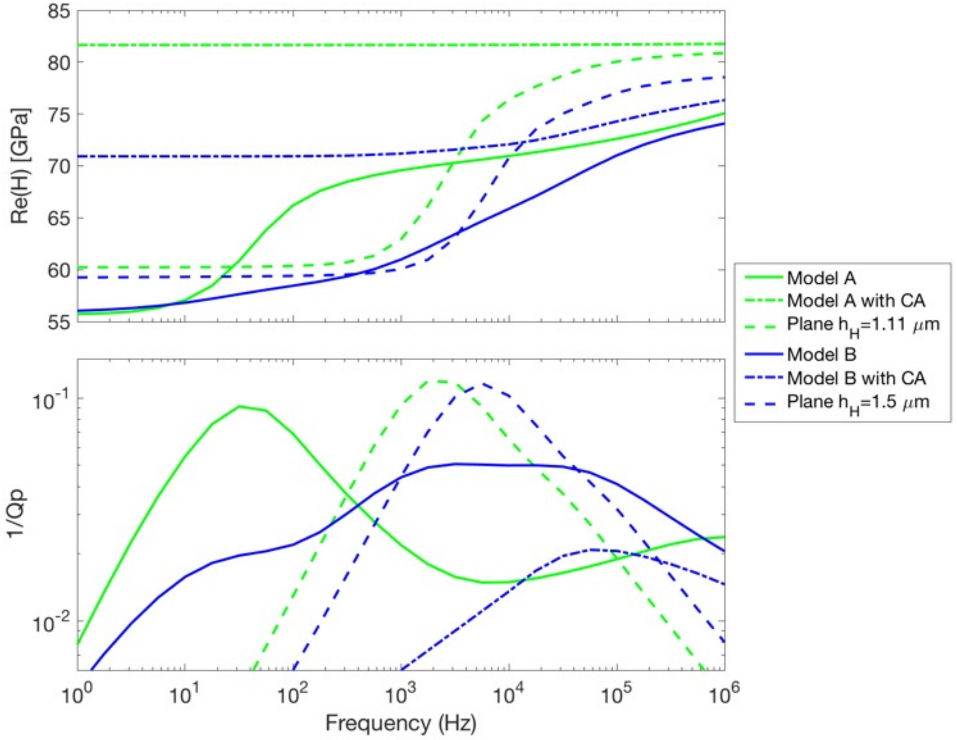


Crack models (binary and fully-variable apertures) with contact areas

Results of models having binary-crack aperture



Results of models having fully variable crack aperture



Conclusions

- Seismic attenuation due to squirt-flow is strongly affected by the roughness of the crack walls.
- The minimum and the hydraulic apertures significantly affect the energy dissipation process.